Rapid inverse design of metamaterials based on prescribed mechanical behavior through machine learning

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Abstract

Designing and printing metamaterials with customizable architectures enables the realization of unprecedented mechanical behaviors that transcend those of their constituent materials. These behaviors are recorded in the form of response curves, with stress-strain curves describing their quasi-static footprint. However, existing inverse design approaches are yet matured to capture the full desired behaviors due to challenges stemmed from multiple design objectives, nonlinear behavior, and process-dependent manufacturing errors. Here, we report a rapid inverse design methodology, leveraging generative machine learning and desktop additive manufacturing, which enables the creation of nearly all possible uniaxial compressive stress■strain curve cases while accounting for process-dependent errors from printing. Results show that mechanical behavior with full tailorability can be achieved with nearly 90% fidelity between target and experimentally measured results. Our approach represents a starting point to inverse design materials that meet prescribed yet complex behaviors and potentially bypasses iterative design-manufacturing cycles.